SUMMARY OF IHRA PEDESTRIAN SAFETY WG ACTIVITIES (2005) - PROPOSED TEST METHODS TO EVALUATE PEDESTRIAN PROTECTION AFFORDED BY PASSENGER CARS

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ABSTRACT

This is the Summary Report of IHRA pedestrian safety working Group activities, which are completed in the past and will be completed in the near future.

INTRODUCTION

The primary tasks assigned to the IHRA/PS-WG were:

a) investigating and analyzing the latest pedestrian accident data in the IHRA member countries, and
b) establishing harmonized test procedures that would reflect such accident condition and would induce fatalities and alleviation of severe injuries in pedestrian vs. passenger car crashes.

These tasks would be carried out with the cooperation of all IHRA member countries.

The members of the IHRA Pedestrian safety Working Group (IHRA/PS-WG) is comprised of experts selected by the governments of Australia, Europe (EC/EEVC), Japan and U.S.A., and experts selected by the industrial organization of OICA and the chairperson selected by Japan.(see Table 11)

Approach of Application Systems

Biomechanics in the aspect of pedestrian accidents and the developments of test devices based on such bio-mechanics are still in the process of research.

A pedestrian dummy had not been developed at the beginning of this project. Also, pedestrian dummies have disadvantages when used as part of test methods to require protection for all statures of pedestrians. IHRA/PS-WG had to give up the idea of using a pedestrian dummy after consulting with the IHRA/Bio-WG. Beside this situation, the WG experts believe the subsystem test method has several merits such as repeatability, simplicity, impact locations of the vehicle can be freely chosen, and cost of the test.

One of the two primary tasks assigned to the IHRA/PS-WG was gathering the results of detailed research into the accidents Data to an agreed format has been collected from Australia, Europe, Japan and USA. The current dataset has been analyzed to determine the impact areas of vehicles, accidents frequency and injured regions of pedestrian vs. passenger car crashes and to decide research priorities from these findings.

According to the priorities thus decided, the WG embarked on its research activities to develop adult and child head protection test methods, and adult lower leg/knee protection test method.

By the end of 2004, the WG has completed adult and child head test methods and adult lower leg/knee test method.

ACCIDENT DATA

The WG agreed that development of harmonized test procedures would be based upon real world crash data. Pertinent pedestrian and vehicle information contained in accident survey databases was accumulated. Pedestrian information included age, stature, gender, injured body region, and injury severity. Vehicle information included vehicle type, make, and year, mass, pedestrian contact location, damage pattern, and impact velocity. Other general accident information such as pedestrian crossing pattern, weather conditions, vehicle and pedestrian trajectories, alcohol use, etc. were also of interest if collected. Bicycle or motor-driven cyclists were not included in the study. Four injury databases from Australia, Germany, Japan, and United States were identified as containing much of this information. Multiple injuries per case were included in the dataset.

In Japan, pedestrian accident data collected by JARI between 1987 and 1988 and in-depth case study data of pedestrian accidents conducted by ITARDA between 1994 and 1998 were combined for inclusion into the IHRA accident dataset. A total of 240 cases were acquired in the cities surrounding the Japan Automobile Research Institute (JARI).

In Germany, investigation teams from both the Automotive Industry Research Association and Federal Road Research Institute collected accident information in a jointly conducted project called the German In-Depth Accident Study (GIDAS). A total of 783 cases collected between 1985 and 1998 were included from the cities of Dresden and Hanover and their surrounding rural areas. The teams selected accidents according to a strict selection process to avoid any bias in the database. Accidents where a passenger car collided with more than one pedestrian or one pedestrian collides with more than one passenger car were not considered. Furthermore, accidents in which the car ran over the pedestrian or the impact speed could not be established were not considered. The study included information such as environmental conditions, accident details, technical vehicle data, impact contact points, and information related to the people involved, such as weight, height, etc.

Detailed information from pedestrian crashes was collected in the United States through the Pedestrian Crash Data Study (PCDS). In this non-stratified study, a total of 521 cases were collected between 1994 and 1999. Cases were collected from six urban sites during weekdays. If, within 24 hours following the accident, the pedestrian could not be located and interviewed or the vehicle damage patterns documented, the case was eliminated from the study. In order for a case to qualify for the study, the vehicle had to be moving forward at the time of impact; the vehicle had to be a late model passenger car, light truck, or van; the pedestrian could not be sitting or lying down; the striking portion of the vehicle had to be equipped with original and previously undamaged equipment; pedestrian impacts had to be the vehicle's only impact; and the first point of contact between the vehicle and the pedestrian had to be forward of the top of the A-pillar.

The Australian data is from at-the-scene investigations in 1999 and 2000 of pedestrian collisions in the Adelaide metropolitan area, which has a general speed limit of 60 km/hr. The sample consists of 80 pedestrian/vehicle collisions, including 64 with passenger cars, SUV and 1-box type vehicles, where the pedestrian was standing, walking, or running, and where the main point of contact with the pedestrian on the vehicle was forward of the top of the A-pillar. Pedestrians and drivers were interviewed, wherever practicable, as part of the investigation process. The reconstruction of the impact speed of the vehicle was based on physical evidence collected at the scene. Injury information was obtained from hospital and coronial records, the South Australian Trauma Registry and, in minor injury cases, from an interview with the pedestrian.

Data from these four studies were combined into a single database for further analysis to develop a better basis for worldwide pedestrian impact conditions. From each of these studies, seven fields of information were identified which were common to all four studies and were crucial to providing guidance in test procedure development. For each injury, these seven fields of data were collected and input into the unified pedestrian accident database. The seven fields were country, case number, pedestrian age, impact speed, AIS injury level, body region injured, and vehicle source causing the injury. Injury body region and vehicle source were categorized as shown in Table 1.

The number of cases and total injuries represented in this combined database are shown in Table 2. Throughout the remainder of this report, this dataset is denoted as the IHRA Pedestrian Accident Dataset. It is recognized that pedestrian injuries in developing countries are not represented in this dataset; however, this data is the most comprehensive pedestrian accident database available to guide pedestrian safety test procedure development. A total of 3,305 injuries of AIS 2-6 severity were observed, and there were 6,158 AIS=1 injuries observed (Table 2).

Table 1. Injury Body Regions and Sources

Injury Body Regions
Head
Face
Neck
Chest
Abdomen
Pelvis
Arms
Leg Overall
Femur
Knee
Lower Leg
Foot
Unknown Injury

Injury Sources
Front Bumper
Bonnet/Wing
Leading Edge
Windscreen Glass
Win. Frame/A-Pillars
Front Panel
Other Vehicle Source
Indirect Contact Injury
Road Surface
Unknown Source

Table 2. IHRA Pedestrian Accident Dataset

Region	Cases	Injuries	AIS 1	AIS2-6
Australia	65	345	182	163
Germany	782	4056	2616	1440
Japan	240	883	523	360
U.S.A.	518	4179	2837	1342
Total	1605	9463	6158	3305

These minor (AIS=1) injuries were excluded in the following analysis because they were not believed to be crucial in test procedure development.

IHRA pedestrian injuries of AIS 2-6 severity are shown in Table 3 according to the part of the body that was injured.

As shown in Table 3, head (31.4%) and legs (32.6%) each accounted for about one-third of the AIS 2-6 pedestrian injuries. Of the 3,305 AIS 2-6 injuries, 2,790 (84%) were caused by contact with portions of the striking vehicle, with head and legs being the most frequently injured. Head injury accounted for 824 occurrences, and legs a total of 986 injuries when combining overall, femur, knee, lower leg, and foot body regions. Windscreen glass was the most frequent vehicle source of head injury, with the windscreen frame/A-pillars and top surface of bonnet/wing both being substantial additional sources of injury to the head. A further breakdown of the injuries and vehicle sources for children and adults is shown in Tables 5-7. For children, the top surface of the bonnet is the leading cause of head injury, while a substantial number of child head injuries also occur from windscreen glass contact. For adults, the windscreen glass is the leading source of head injury, followed by windscreen frame/A-pillars and top surface of the bonnet and wing. Not surprisingly, the bumper was the leading source for both child and adult pedestrian leg injury. Distribution of pedestrian accident victims by age (all AIS levels) is shown in Table 4 and illustrated in Figure 1.

Table3.
Distributions of Pedestrian Injury (AIS 2-6)

Body Region	USA	Germany	Japan	Australia	TOTAL
Head	32.7%	29.9%	28.9%	39.3%	31.4%
Face	3.7%	5.2%	2.2%	3.7%	4.2%
Neck	0.0%	1.7%	4.7%	3.1%	1.4%
Chest	9.4%	11.7%	8.6%	10.4%	10.3%
Abdomen	7.7%	3.4%	4.7%	4.9%	5.4%
Pelvis	5.3%	7.9%	4.4%	4.9%	6.3%
Arms	7.9%	8.2%	9.2%	8.0%	8.2%
Legs	33.3%	31.6%	37.2%	25.8%	32.6%
Unknown	0.0%	0.4%	0.0%	0.0%	0.2%
TOTAL	100%	100%	100%	100%	100%

When broken into five-year age segments, Table 4 indicates that the 6–10 year old age group has the highest frequency of accident involvement at nearly 14% of all cases. In Japan, this age segment accounts for 20% of the cases, while the other three countries have lower involvements in this age group. The percentage involvement in the 11-15 year old group for Japan, however, drops considerably and is lower than for Germany, the U.S., or Australia. It is unclear why this sudden drop occurs in Japan and not in the other countries. In summary, over 31% of all cases involved pedestrians age 15 and younger. This percentage is 13% higher than the average overall population of individuals in this age group in the four countries (18%), which demonstrates the magnitude of the child pedestrian problem.

Table4. Distribution of Pedestrian Crashes by Age and Country

Age	US	Germany	Japan	Australia	IHRA
0-5	4.6%	9.0%	9.2%	4.3%	7.3%
6-10	13.8%	14.6%	20.0%	10.6%	14.1%
11-15	13.8%	9.8%	5.0%	11.0%	9.7%
16-20	6.2%	7.3%	3.3%	7.2%	6.6%
21-25	6.2%	4.5%	1.7%	8.7%	5.5%
26-30	4.6%	4.7%	1.7%	10.1%	6.0%
31-35	4.6%	4.2%	5.4%	5.8%	4.9%
36-40	3.1%	4.5%	5.0%	7.2%	5.4%
41-45	3.1%	3.6%	3.8%	6.2%	4.4%
46-50	3.1%	4.6%	5.4%	6.2%	5.2%
51-55	3.1%	5.4%	6.7%	3.3%	4.8%
56-60	1.5%	4.5%	10.0%	3.7%	4.9%
61-65	6.2%	5.8%	6.7%	3.9%	5.3%
66-70	7.7%	3.7%	3.8%	3.3%	3.7%
71-75	4.6%	3.8%	4.2%	3.7%	3.9%
76-80	3.1%	5.0%	2.5%	3.3%	4.0%
81-85	6.2%	3.8%	3.3%	0.8%	2.9%
86-90	4.6%	1.2%	2.1%	0.4%	1.2%
91-95	0.0%	0.1%	0.0%	0.6%	0.2%
96-100	0.0%	0.0%	0.4%	0.0%	0.1%

The age distribution data contained in Figure 1 also provides an opportunity to demonstrate that the IHRA Pedestrian Accident Dataset is representative of the pedestrian crash situation in the United States. In addition to the Germany, Japan, U.S., and Australian pedestrian datasets, data from the FARS and GES are also included. FARS is the Fatal Analysis Reporting System, which contains every fatal traffic accident in the U.S. The GES is the General Estimates System, and is obtained from a nationally representative sampling of police-reported crashes. In general, the age distribution of the GES data is similar to the others in Figure 1.

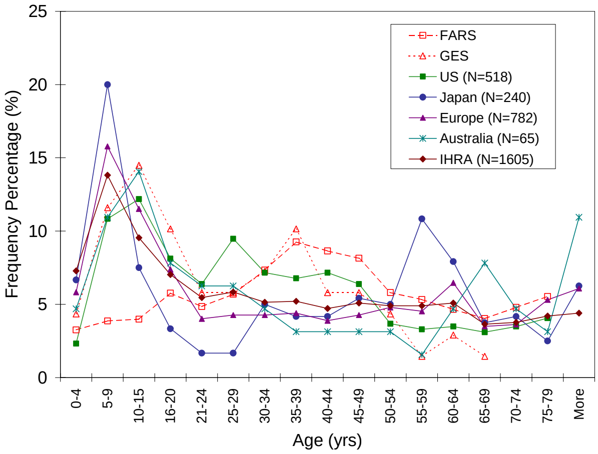

Figure1.
Frequency of Accidents by Age and Country

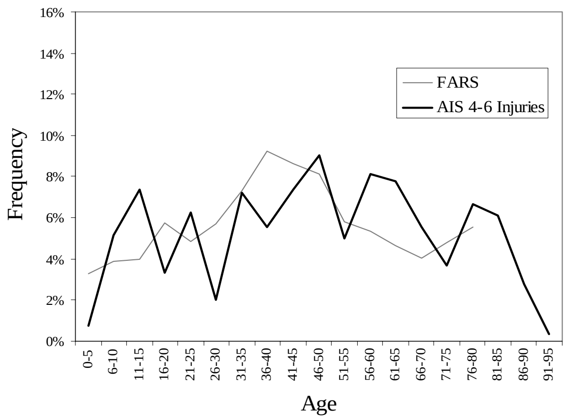

Figure 2.
IHRA AIS 4-6 Injuries vs. FARS Data by Age

Since the GES is designed to be a statistically representative sample, and since the U.S. PCDS and GES distributions are similar, this would imply that the PCDS is fairly statistically representative despite the non-stratified sampling scheme used to collect PCDS cases. However, the FARS distribution differs significantly from any of the others in Figure 1. Because FARS contains only fatal accidents, this may be an indication that the distribution of fatal and non-fatal injuries differs from each other. An ideal comparison for the FARS data would have been with the IHRA pedestrian fatalities. But since the number of fatal cases is quite limited in the IHRA data, the FARS distribution was compared to the serious and fatal AIS≥4 injuries as shown in Figure 2. Although there is considerable variability remaining in this distribution due to small sample sizes, the FARS distribution has reasonable agreement with the IHRA data.

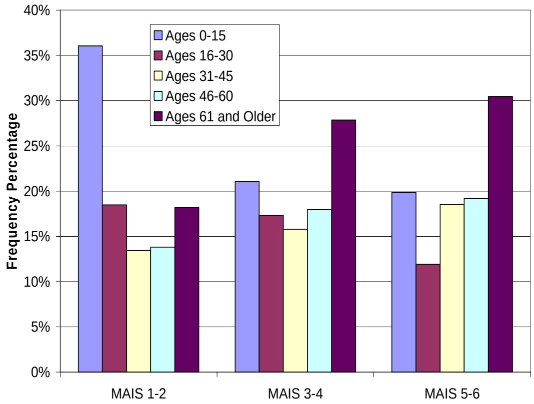

Figure 3. Distributions of MAIS Levels by Age

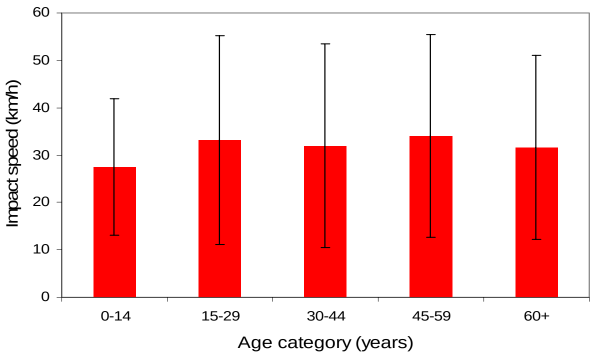

Figure 4. Average Impact Velocities by Age Group (MAIS 1-6)

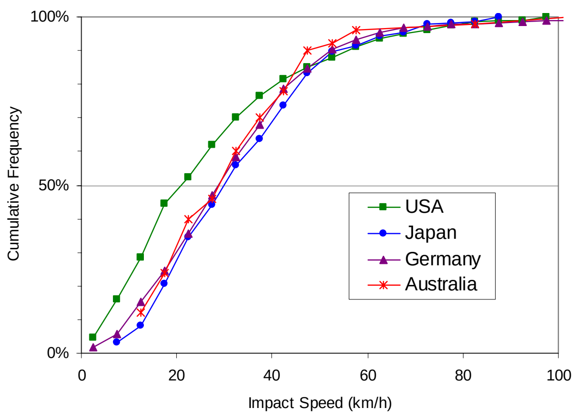

Figure 5. Impact Velocities by Country

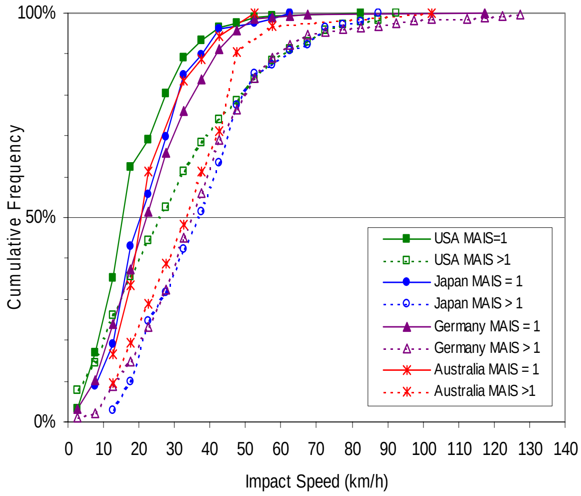

Figure 6. Impact Velocities by MAIS Level

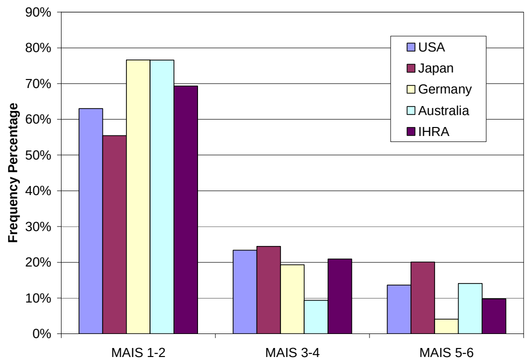

Figure 7. MAIS Injury by Country

Analysis of the injury level by age group is shown in Figure 3. This figure shows that children aged 15 and younger tend to have a higher proportion (25%) of AIS 1 and 2 injuries than adults, and persons aged 61 and older have the highest proportion (near 30%) of moderate and serious injuries. These observations are likely the result of two factors. First of all, exposure levels may differ for the various age groups. For example, younger children tend to be involved in pedestrian collisions with lower impact velocities. As shown in Figure 4, the average impact velocity for children aged 0-14 is about 28 km/h. This is approximately 5 km/h lower than for the other age groups. A second cause of the injury distribution observed in Figure 3 may be that those aged 60 years and older are generally more frail and less resilient, leading to higher severity injury for a given impact velocity.

Figures 5 and 6 provide insight into the impact velocity distribution associated with pedestrian impacts. In Figure 5, the cumulative frequency of impact velocities on a per case basis for each country is similar although the U.S. has a larger percentage of injuries at lower velocities than the other three countries. This is broken down further in Figure 6, where lower MAIS injuries occur at lower velocities for all four countries. In Figure 7, the MAIS injuries are broken into three categories for the four countries. For MAIS 1-2 injuries, Japan has the lowest frequency (55%) and Germany has the highest (77%). For MAIS 3-4 injuries, Australia has the lowest frequency percentage (9%) and Japan has the highest (24%). Finally, for the most severe injuries (MAIS 5-6), Germany has the lowest frequency (4%) and Japan has the highest likelihood of a life-threatening injury (20%).

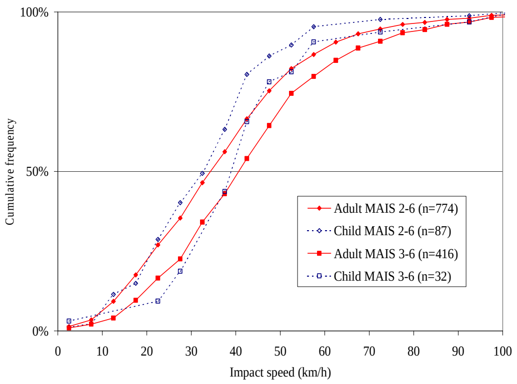

Figure 8. Impact Velocities by MAIS Level – All Body Regions

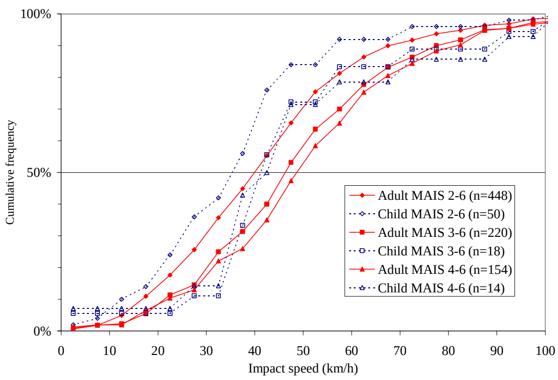

Figure 9. Impact Velocities by MAIS Level - Head Injuries

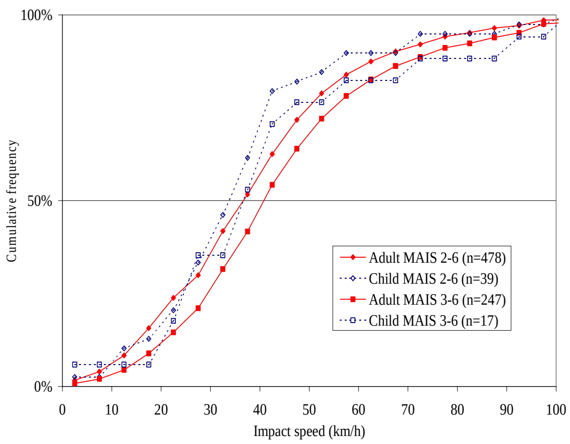

Figure 10. Impact Velocities by MAIS Level – Leg Injuries

The cumulative MAIS injury distributions are further broken down by age, body region, and injury severity in Figures 8 – 10. Age classifications are grouped as children (age 15 years and younger) and adults (age 16 years and older). All body regions are included for both children and adults in Figure 8, with distributions shown for MAIS 2-6 and MAIS 3-6 injuries. The injury distribution distinction between children and adults is evident in this figure. Children (ages 15 and under) are injured at slightly lower impact velocities than adults in most cases.

Head injury distributions are shown in Figure 9. For adults, the MAIS 3-6 and MAIS 4-6 injury distributions are almost identical, while the MAIS 2-6 distribution occurs at lower velocities. For children, there is similar separation between the MAIS 2-6, 3-6, and 4-6 injury curves, and the distributions are roughly the relationship between injury severity and impact velocity.

Injury distributions for children and adult leg injuries are shown in Figure 10. This figure shows that for leg injuries, injury severity is affected less by impact velocity than for head injuries. Once again, children suffer leg injuries at lower velocities than do adults.

The major conclusions from this analysis are:

1. The head and legs each account for almost one-third of the 9,463 injuries in the IHRA dataset.
2. For children, the top surface of the bonnet is the leading cause of head injury, while for adults the windscreen glass is the leading source of head injury.
3. Children (ages 15 and under) account for nearly one-third of all injuries in the dataset, even though they constitute only 18% of the population in the four countries.
4. Older individuals are more likely to suffer severe injuries in pedestrian crashes.
5. Children (ages 15 and under) are injured at lower impact velocities than are adults

This compilation of pedestrian accident data from Australia, Germany, Japan, and U.S.A. provides a unique and important dataset. In this section, MAIS for each case was used instead of all injuries in Figures 3 -10 to eliminate the possibility of cases with more injuries skewing the data. The cumulative injury distribution data will provide a basis for establishing component pedestrian protection test procedures, priorities, and potential benefits assessments.

Table 5.
IHRA Pedestrian Injuries by Body Region and Vehicle Contact Source – All Age Groups; AIS 2-6

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	24	2		3	5	3	6	19	59	76	476	31	1	705
	Top surface of bonnet/wing	223	15	2	139	44	43	86	23	3	1	1	2	1	583
	Leading edge of bonnet/wing	15	2	4	43	78	85	35	50	40	6	30	1		389
	Windscreen glass	344	56	12	30	5	12	23	2			1	1	1	487
	Windscreen frame/A pillars	168	28	5	35	7	14	31	5	1				2	296
	Front Panel	5	1		9	13	7	6	9	14	11	35	3		113
	Others	45	7	1	38	12	13	15	15	9	5	39	18		217
	Sub-Total	824	111	24	297	164	177	202	123	126	99	582	56	5	2790
	Indirect Contact Injury	13		17	1	1	7	1		3		1	2		46
	Road Surface Contact	171	22	2	22	2	9	42	6	4	3	5	15	1	304
	Unknown	27	6	3	19	10	16	25	1	7	9	32	3	7	165
	Total	1035	139	46	339	177	209	270	130	140	111	620	76	13	3305

Table 6.
IHRA Pedestrian Injuries by Region and Vehicle Contact Source – Adult (Ages > 15); AIS 2-6

Contact Location \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	20	2		2	3	3	3	16	29	69	429	29		605
	Top surface of bonnet/wing	140	9	1	122	39	35	73	21	3	1	1	2	1	448
	Leading edge of bonnet/wing	7	2	1	36	65	80	28	46	33	5	24	1		328
	Windscreen glass	303	52	11	28	3	10	22	1			1	1		432
	Windscreen frame/A pillars	159	28	5	34	7	14	29	5	1				2	284
	Front Panel		1		8	13	6	5	9	9	10	32	3		96
	Others	33	7		29	9	12	11	6	4	5	26	13		155
	Sub-Total	662	101	18	259	139	160	171	104	79	90	513	49	3	2348
	Indirect Contact Injury	12		16	1		7			3		1	2		42
	Road Surface Contact	125	18	2	21	2	8	32	6	4	3	5	14	1	241
	Unknown	19	6	3	18	9	16	20	1	4	9	28	3	6	142
	Total	818	125	39	299	150	191	223	111	90	102	547	68	10	2773

Table 7.
IHRA Pedestrian Injuries by Body Region and Vehicle Contact Source – Child (Ages < 16); AIS 2-6

Contact Location \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	4			1	2		3	3	30	7	47	2	1	100
	Top surface of bonnet/wing	83	6	1	17	5	8	13	2						135
	Leading edge of bonnet/wing	8		3	7	13	5	7	4	7	1	6			61
	Windscreen glass	41	4	1	2	2	2	1	1					1	55
	Windscreen frame/A pillars	9			1			2							12
	Front Panel	5			1		1	1		5	1	3			17
	Others	12		1	9	3	1	4	9	5		13	5		62
	Sub-Total	162	10	6	38	25	17	31	19	47	9	69	7	2	442
	Indirect Contact Injury	1		1		1		1							4
	Road Surface Contact	46	4		1		1	10					1		63
	Unknown	8			1	1		5		3		4		1	23
	Total	217	14	7	40	27	18	47	19	50	9	73	8	3	532

VEHICLE SHAPES AND CATEGORIES

Front shape of passenger cars were investigated and categorized into three groups, Sedan, SUV (Sport Utility Vehicle) and 1-Box (One Box Vehicle), so that the effect of vehicle front shapes on the pedestrian impact were studied with computer simulations focusing on the head impact velocity, head impact angle, WAD (Wrap Around Distance) and head effective mass.

Figure 11 shows the car front shape corridors for the three groups obtained from current production cars in Europe, Japan and U.S.A. Each corridor consists of upper and lower boundaries of the bonnet and windscreen glass with the front skirt corridors.

Figure 12 shows the definitions of the measuring points for the bumper lead (BL), bumper center height (BCH), leading edge height (LEH), bonnet length, bonnet angle, windscreen angle and the bottom depth and height of the front skirt. These positions and angles for the lower, middle and upper boundaries of the corridors for each group were summarized in Table 8.

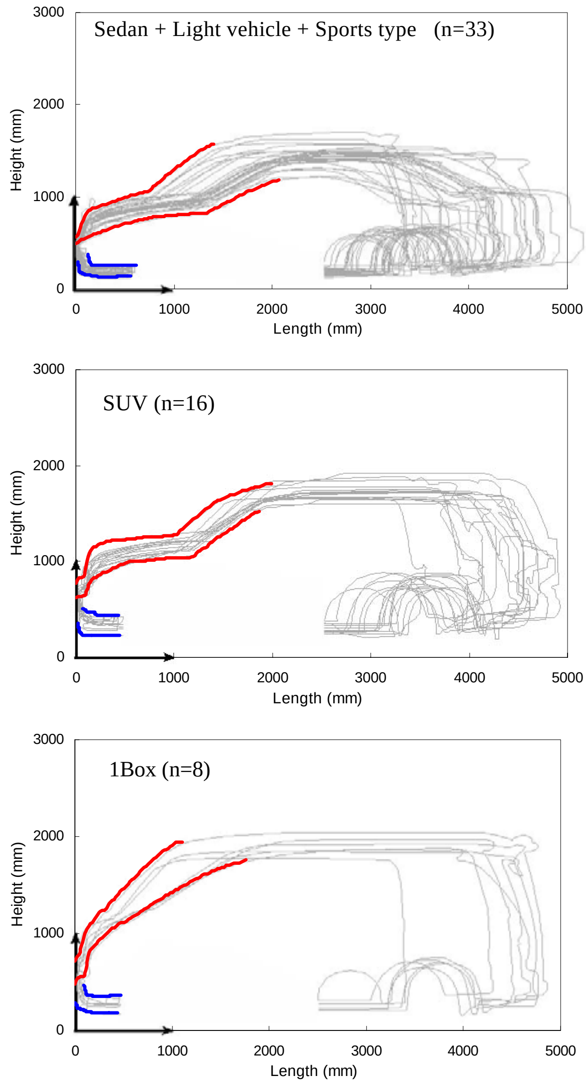

Figure 11. Car Front Shape Corridors

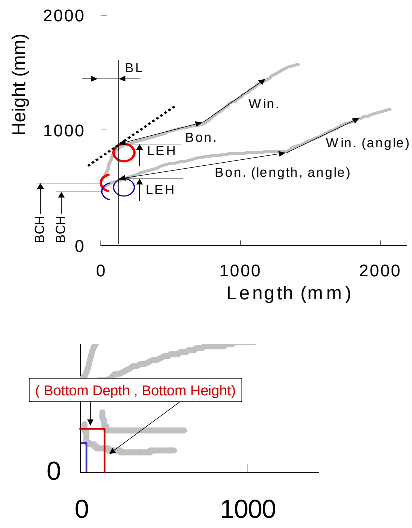

Figure 12. Definitions of Car Front Shape

Table 8. Car Fron Shape Corridors

		Lower	Middle	Upper
Sedan + Light vehicle + Sports type				
		Lower	Middle	Upper
BL	(mm)	127	127	127
BCH	(mm)	435	475.5	516
LEH	(mm)	565	702	839
Bon. length	(mm)	1200	917.5	635
Bon. angle	(deg.)	11	14.5	18
Win. angle	(deg.)	29	34.5	40
Bottom depth	(mm)	42	98	154
Bottom height	(mm)	182	225.5	269
SUV				
		Lower	Middle	Upper
BL	(mm)	195	195	195
BCH	(mm)	544	640	736
LEH	(mm)	832	1000	1168
Bon. length	(mm)	1023	933.5	844
Bon. angle	(deg.)	11	9.75	8.5
Win. angle	(deg.)	36	39.5	43
Bottom depth	(mm)	48	123	198
Bottom height	(mm)	248	348	448
1Box				
		Lower	Middle	Upper
BL	(mm)	188	188	188
BCH	(mm)	448	576	704
LEH	(mm)	864	1004	1144
Bon. length	(mm)	361	259	157
Bon. angle	(deg.)	40	40	40
Win. angle	(deg.)	30	38	46
Bottom depth	(mm)	63	95	127
Bottom height	(mm)	214	292.5	371

BIOMECHANICS

Head Injury Biomechanics

The characteristics of the impact to the head of a pedestrian also differ, to a lesser degree, from those of the impact to the head of a vehicle occupant. The objects struck are, of course, different and the distribution of impact points on the head also differs, with the pedestrian's head being more likely to be struck on the rear or the side compared with the predominantly frontal, with some lateral, impacts to the head of the vehicle occupant. (McLean et al, 1996A & B) However, for both pedestrians and car occupants, severe head injuries are most likely to be a consequence of a head impact with some part of the front of the vehicle, including the windscreen area and surrounds. A head impact with the road surface is less likely than a head impact with the car to be the cause of the most significant brain injury to a pedestrian. (Ashton et al, 1982)

The head is the most common site of fatal injuries to a pedestrian struck by a passenger car, either alone or in combination with one or more fatal injuries to other body regions.

The location of a pedestrian head impact on the striking car depends largely on the size and shape of the car and the height of the pedestrian. The speed of the car on impact also influences the head impact location on the vehicle. For an adult pedestrian the head impact location on the car is therefore usually towards the rear of the bonnet or on the windscreen or an A-pillar. It may extend back as far as the top of the windshield or, in exceptional cases, the roof of the car.

The head, and probably the upper torso, had been rotated through approximately 90 degrees about the longitudinal axis of the body in the 100 to 150 milliseconds between the bumper striking the legs and the head hitting the car. This whole body rotation is thought to be a consequence of the motion of the legs on impact by the front of the car.

Despite the rotation of the upper body and head of the pedestrian prior to the head striking the car, the high proportion of impacts on the back of the head indicates that the resulting acceleration of the head is likely to be predominantly linear rather than angular. This will be less so in those cases in which the impact is on the side of the head. (Ryan et al, 1989) However, even then, impacts which may result in a high level of angular acceleration of the head can also be expected to produce a high level of linear acceleration. The evidence for the roles of linear and angular acceleration in the production of brain injury is reviewed elsewhere. (McLean and Anderson, 1997)

For the purposes of this Working Group, emphasis has been placed on pedestrian head injuries resulting from head impact with the vehicle frontal structure, including the windscreen and A-pillars. The Head Injury Criterion (HIC) has been selected as the measure of the risk of brain injury resulting from these impacts. It is recognized that HIC evolved from the relationship between the duration of the impact applied to the frontal bone of the skull of a post mortem human subject, head acceleration, and the risk of the impact producing a skull fracture. It also does not allow for the influence of some factors, such as rotational acceleration of the head, or any effect of the location of the impact on the head, but it has been selected here because, at present, it is used almost universally in crash injury research. The time window for the calculation of HIC has been set at a maximum of 15 milliseconds and the value of HIC shall not exceed 1000. That HIC level is thought to correspond to a 16 per cent risk of sustaining a head injury as severe as AIS 4 or greater. (Mertz et al, 1997)

Two head forms are proposed for use in subsystem testing, one representing the head of a 50th percentile adult and the other the head of a 6 year old child. The diameter of each head form is 165 mm and the mass is 4.5 kg for the adult head form and 3.5 kg for the child. The head forms are subject to performance, rather than design criteria. The head impact test areas on the vehicle for the child and adult head forms correspond to the areas commonly struck by the head of a child and an adult pedestrian, respectively.

Injuries to lower limbs

The pedestrian lower limb is typically loaded from the side (80-90%). Such loading conditions differ from those of lower limb of vehicle driver/occupant that are likely to be impacted in direction parallel to sagittal plane. These conditions result in injuries unique to the pedestrian-car collision. Such injuries are typically a consequence of contact between the lower limb and components of a car front, such as bumper, bonnet and bonnet leading edge. They are one of the most common types of injury in non-fatal pedestrian-car collisions. For instance, in the accident data investigated by Ashton and Mackay (1979) injuries to lower limbs were sustained by 67% of victims with minor injuries and 72% of victims with non-minor, non-life threatening injuries. Similarly, more recent Japanese data (ITARDA, 1996) have indicated that lower limbs are the most commonly injured body part (40%) with the most severe injury.

The pattern of lower limb injuries differs between children and adults, and it has been reported in the literature that the frequency of these injuries is higher for adults than for children (Ashton, 1986). Furthermore, children are less likely to sustain pelvic and leg fractures than adults. For instance, in the UK accident data analyzed by Ashton (1986), the leg fractures have not been observed in children aged below 5 years, and the children aged 0-4 years sustained mainly femur fractures. It is clear that this injury pattern is caused by the fact that the bumper directly impacts a young child thigh.

However, it seems that insufficient experimental data are available to quantify the responses of child lower limbs in pedestrian-car collision. Therefore, the present review is concentrated on injuries to the leg and knee joint of adult pedestrian.

Severity of Injuries to Lower Limbs

Injuries to the lower limbs are rarely fatal. They involve fractures of fibula, tibia, and femur, as well as avulsion, rupture, and stretching of the knee joint ligaments. Such injuries are typically classified as AIS 1 to 3 (i.e., minor to serious injuries). However, they often require appreciably longer hospitalization and loss of working days than do injuries at the same AIS levels to other body regions. For instance, in the clinical study by Bunkentorp et al. (1982) healing time of tibia shaft fractures were 4-34 months, and only half of the fractures healed within 8 months. The healing time of knee and ankle injuries in their study was 2-7 months.

Injury Types and Injury Mechanisms to the Lower Limb of a Pedestrian

Injuries to the lower limb that have been observed in the PMHS experiments simulating pedestrian-car collisions and clinical studies are mainly fractures of tibia diaphysis (transverse and comminute fractures of the shaft), articular fractures of tibia, cartilage damages on femoral condyles, and avulsion/stretching of the knee joint ligaments (Bunkentorp, 1982; Kajzer et al., 1997 and 1999).

The injury type depends on the following factors: 1) impact point, 2) car front part impacting the lower limb, and 3) the impact speed (*e.g.,* fracture risk is likely to increase at high impact speed). According to Bunkentorp et al. (1982), a bumper impact at or just below the knee joint is correlated with high risk of serious knee injury. Such injury may be also caused by a prominent bonnet edge. However, the bumper seems to be the main cause of injury to leg and knee joint in adult pedestrians.

Injury Mechanisms

According to Kajzer et al. (1997, 1999) two fundamental mechanisms of injury to the knee joint can be distinguished: 1) shearing and 2) bending. The shearing mechanism is related to translational displacement in lateral direction between the proximal leg and distal thigh at the knee joint. On the other hand, the bending injury mechanism is related to angular displacement between the leg and thigh. Following these two injury mechanisms, two extreme loading conditions can be distinguished. The first of them corresponds to “the purest possible shearing deformation” of the knee joint (i.e., lateral impact to the leg slightly below the knee joint), whereas the second one — to “the purest possible bending deformation” of this joint (i.e., lateral impact to the distal leg end).

The typical initial injury (i.e., the injury that occurred first in a given test) associated with the shearing-type loading conditions observed by Kajzer et al. (1997, 1999) was articular fractures and anterior cruciate ligament avulsion in impacts using ram speeds of 40 km/h and 20 km/h, respectively. The articular fractures were caused by axial compressive force between femoral and tibial condyles (Fig. 13). On the other hand, typical initial injury related to the bending-type loading at low impact speed (i.e., 20 km/h) reported by Kajzer et al. (1999) was avulsion/stretching of the collateral ligament on the leg side opposite to the struck area.

Furthermore, based on analysis of both the experimental data obtained using PMHS and results of mathematical modeling, it has been suggested by Yang (1997) that the risk of tibia/fibula fracture and ligament avulsion/rupture may not be independent since such fracture may protect the knee joint ligaments from injury by absorbing the impact energy.

As for the long bone fracture, a bending moment and an accelerometer can be a candidate for the injury criterion.

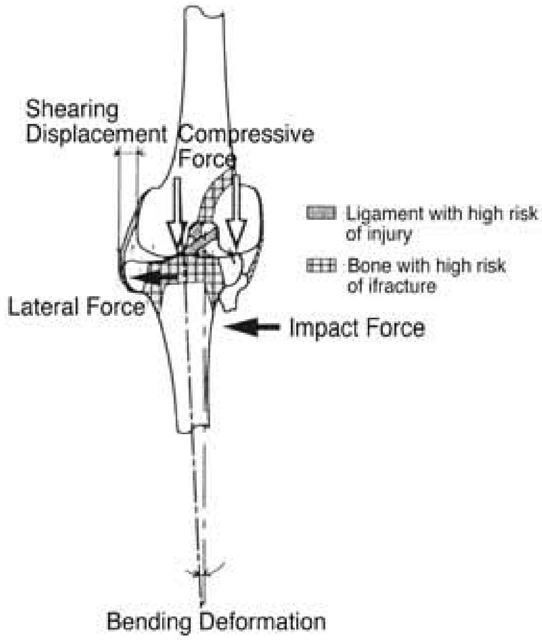

Figure 13. Injuries resulting from shearing-type loading conditions at ram speed of 40 km/h. Based on Kajzer et al. (1997).

Indicators of Injury Risk to Leg and Knee Joint Suggestions for Biofidelity Requirements for Leg-form

Summary of shearing and bending injury mechanisms presented in the previous section suggests that the injury risk to the leg and knee joint can be described by means of the following four variables: 1) shearing displacement (i.e., lateral displacement between proximal leg and distal thigh at the knee joint), 2) knee joint angle (i.e., relative angular displacement between the leg and thigh), 3) impact force (i.e., force between the leg and object striking it), and 4) knee ligaments (MCL, ACL, PCL, LCL) elongations. It seems reasonable to use these variables in evaluation of the biofidelity of legform impactors.

Corridors (average -/+ standard deviation) of impact force, shearing displacement and knee angle-time histories for such evaluation have been determined by Matsui et al. (1999) and Wittek et. al. (2000)

using the PMHS experimental data of Kajzer et al. (1997, 1999). Cesari D. et. al. (2004) also developed pedestrian lower extremity corridors using the PMHS experimental data of Kajzer et. al. (1991, 1994). Besides these works, Ivarsson et. al. (2004) developed thigh, leg, and knee joint response corridor, and these corridors are can be utilized to evaluate a legform impactor biofidelity.

COMPUTER SIMULATION OF PEDESTRIAN HEAD IMPACTS

Computer simulation has been used by the Pedestrian Safety Working Group to study the influence of vehicle shape and pedestrian anthropometry and posture on the impact conditions required of sub-system testing. These impact conditions are the mass, speed and angle of the subsystem impactors, with reference at this stage to the reconstruction of head impacts involving a 50th percentile male. Computer simulation also shows promise for use in the study of possible interactions between the results of subsystem tests. For example, is it possible that a particular measure that reduces the risk of a severe injury to the knee joint may increase the risk of a severe head injury?

The pedestrian-vehicle simulations that have been performed have made use of multi body dynamic codes such as MADYMO (TNO, Delft, the Netherlands) in which the pedestrian is represented by a tree structure of rigid links, connected with kinematics joints. Properties of the model that are specified include the mass and moments of inertia of each link, the properties of the kinematics joints, the geometry of the contact surfaces of each link and their contact properties. The front of the vehicle, back to the upper frame of the windscreen, is similarly described.

The properties of such models are based on studies of the joints and body segments of post-mortem human subjects and/or human volunteers. The behavior of the model can be validated by confirming that its response is similar to the response of human joints and body segments when subjected to dynamic loads in experiments. Pedestrian models can also be compared to the kinematics of post mortem human subjects subjected to experimental impacts by a vehicle and also to the results of detailed investigations of actual pedestrian-vehicle collisions in those cases in which a reasonable estimate of the impact speed of the striking vehicle is available.

Three computer models have been used by the Japan Automobile Research Institute, the United States National Highway Traffic Safety Administration (using a TNO computer model), and the Centre for Automotive Safety Research (previously the Road Accident Research Unit) of Adelaide University, Australia, for the purposes of this Working Group. Each of the models was used to simulate experiments with cadavers, as an initial assessment of the biofidelity of the kinematics of the model. The results for three output parameters relating to head impacts with the bonnet, where relevant, and the windscreen are summarized in Tables 9-10 for three categories of vehicle frontal shape. These parameters are:

(1) Head impact speed divided by the vehicle impact speed (values shown are average +/_ 1 SD)

(2) Head impact angle (values shown are average +/_ 1 SD)

Table 9. Summary of Parameter Study for Adult
(Car Impact Speed: 30, 40 and 50 Km/h)

For Adult

Shape Corridor	Car impact speed 30km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	23.7 +/- 6.0	27.3 +/- 5.4	nc	78.3 +/- 5.6	48.8 +/- 9.9	nc
SUV	26.4 +/- 3.6	nc	nc	73.8 +/- 21.5	nc	nc
One box	nc	20.4 +/- 3.6	nc	nc	55.1 +/- 10.4	nc

Shaep Corridor	Car impact speed 40km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	30.4 +/- 7.2	35.2 +/- 6.8	nc	66.0 +/- 14.0	38.4 +/- 10.9	nc
SUV	30.8 +/- 8.8	nc	nc	76.7 +/- 22.2	nc	nc
One box	nc	29.6 +/- 3.2	nc	nc	47.3 +/- 9.6	nc

Shaep Corridor	Car impact speed 50km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	37.5 +/- 9.5	46.5 +/- 11.0	nc	56.8 +/- 11.5	33.5 +/- 11.3	nc
SUV	39.5 +/- 11.0	nc	nc	73.5 +/- 25.2	nc	nc
One box	nc	43.0 +/- 6.0	nc	nc	38.4 +/- 12.3	nc

*nc: No Contact
** Linear interpretation to be used to determine impact conditions for in-between speeds if required.

Table 10. Summary of Parameter Study for Child (Car Impact Speed: 30, 40, and 50 Km/h)

For Child

Shaep Corridor	Car impact speed 30km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	21.6 +/- 3.0	nc	nc	65.1 +/- 0.8	nc	nc
SUV	21.3 +/- 1.2	nc	21.3 +/- 6.0	55.6 +/- 5.5	nc	26.0 +/- 7.5
One box	20.1 +/- 0.6	nc	21.9 +/- 5.1	47.5 +/- 2.8	nc	20.3 +/- 8.0

Shaep Corridor	Car impact speed 40km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	30.0 +/- 4.0	nc	nc	66.0 +/- 6.3	nc	nc
SUV	27.2 +/- 1.6	nc	32.0 +/- 3.6	59.2 +/- 2.6	nc	22.5 +/- 4.2
One box	27.6 +/- 0.8	nc	33.2 +/- 3.2	49.8 +/- 1.8	nc	17.4 +/- 6.1

Shaep Corridor	Car impact speed 50km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windsheld	BLE/Grille	Bonnet	Windsheld	BLE/Grille
Sedan +	38.5 +/- 5.0	nc	nc	65.2 +/- 6.5	nc	nc
SUV	34.0 +/- 1.5	nc	44.5 +/- 1.0	61.9 +/- 3.8	nc	18.1 +/- 3.8
One box	36 +/- 0.5	nc	46.5 +/- 2.0	47.4 +/- 2.1	nc	14.8 +/- 3.6

*nc: No Contact
** Linear interpretation to be used to determine impact conditions for in-between speeds if required.

TEST METHODS

IHRA/PS decided to adopt head and leg sub-system test methods and to establish specifications. That means that test procedures were drafted for each of the sub-systems. Two head-forms are proposed for use in head sub-system testing, one to represent an adult pedestrian head and one to represent a child pedestrian head. They are defined as falling in the height range of typical adults or children respectively, provided that short adults are included in the height range of children. The group also set forth a leg test procedure, for which the specifications of a leg-form are, defined. The test procedures are such that these head-forms and leg-forms are subject to performance rather than selection of particular design.

HEAD

Mathematical simulations of head impact against different categories of shapes of cars, defined previously, were performed. They focused on head effective mass, head impact speed and angle at impact, and also wrap around distance at the head contact point, as described in the former section.

Head-form Specifications

Mass and dimensions

The results of these simulations indicated that the effective head mass of the head varied throughout the contact period and so some averaging of the effective mass function over the relevant impact period was required to determine a single value for the effective mass. The simulation results also showed a large variation in head effective mass depending on vehicle shape. Within the test method, it was also clearly undesirable to require head-forms of different masses for vehicles of different front shapes, as IHRA/PS wanted to produce simple and repetitive test procedures.

It was noted that for the average effective mass for all vehicle shapes simulated was almost comparable to the head mass itself for cases of bonnet contacts, whereas the average effective mass is about 80 % of the head mass for cases of windscreen contacts. Therefore, based on this and engineer judgment, IHRA/PS decided to take the average effective mass for all vehicle shapes and to specify only one value of mass for an adult headform and one value for a child headform.

The mass for the adult headform was chosen to be 4.5 kg, which is the mass of the head of the 50th percentile male human being. This is the total impactor mass including instrumentation. Based on studies of human head dimension, a diameter was chosen which the same is as both EEVC and ISO test procedures of 165 mm. This value was reportedly based on existing documents including SAE J921 and was considered to represent the diameter mainly of the forehead portion.

The distribution of pedestrian victims by group of age indicates that the age group around 6 years old has the highest frequency of pedestrian accidents involvement at nearly 14% of all the cases. For this reason, it was decided to consider a head-form representing the head of a six years old child.

According to the recommendations of ISO working group of Biomechanics (ISO/TC22/SC12/WG5), the average mass of the six year old child head is 3.48

kg, which has been rounded to 3.5 kg. IHRA decided to also select 3.5kg for the mass of the child headform.
The only data available for the dimensions of a 6-years old child head are the circumference of the head which is 523 mm, the width which is 141 mm and the A-P length which is 180 mm. From these values one can determine the diameter, either by taking the average of the two dimensions, A-P and width, (141 +180)/2 =161 mm or from the circumference, which leads to a value of 166 mm. So it is decided, for the child head-form, to use the same value as for the adult head-form of 165mm.

Moment of inertia

With regard to the moments of inertia, a comprehensive study on the influence of moment of inertia of a head-form impactor on HIC was conducted, and it was concluded that the influence is not significant. Consequently, IHRA/PS WG decided the moment of inertia specification for the adult and child head-form impactor should be 0.0075 – 0.02 kgm^2.

Test procedures

The test procedures are based on the accident statistics, the results of the computer simulations, cadaver tests, and engineering judgment. The latter is applied to create sufficiently simple and repeatable s suitable for use in regulations.

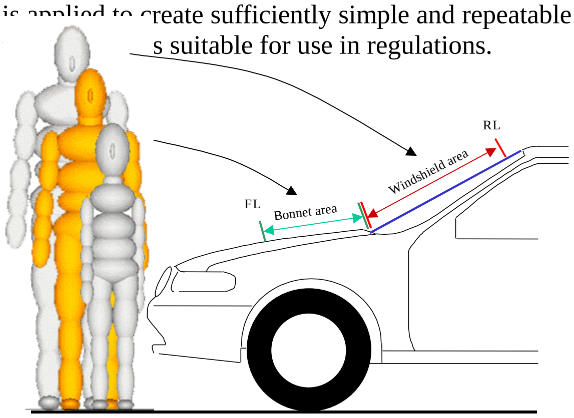

Figure 14. Principles of headform impactor test

According to the accident data of Australia, Europe, Japan, and United States, the 50th percentile impact speed between a pedestrian and a car was 25-30 km/h. For the injury level of AIS 3 or over, the corresponding speed was 50-55 km/h. According to the accident data of Australia, the 50th percentile impact speed was 50-60 km/h. The computer simulations for a child indicated that the head impact speed equals to 80% of the car impact speed. On the other hand, a PMHS test for adult indicated that such ratio for the head impact speed against car impact speed varies widely between 80% and 150%.
The values for the head impact speed related to the vehicle impact speed in simulations of a head collision with the bonnet or the windshield show significantly different results according to the simulation model and vehicle shape used; the average ratio varies significantly from 0.7 to 1.1 according to vehicle shape. Also, there are differences between contacts on the bonnet and contacts on the windscreen, due to the big differences in terms of impact conditions. Based on the PMHS test and simulation result data variations as well as concerns about the biofidelity of the human models used in the computer simulation, the IHRA PS WG could not come to a solid conclusion to use average ratio of head-to-vehicle ratio for all vehicle shapes. However, the IHRA/PS group believed the information is best available information at the present time. Finally, a lookup table is provided by average +/- 1 SD, that give the user the option to test anywhere within the tolerance window depending upon the desired level of stringency.
For future work, the JARI pedestrian model was selected as a base model, and now IHRA/PS members are developing an IHRA pedestrian model (IHRA-PED). Therefore, in the future, the IHRA-PED will be developed and will be used to update the current IHRA/PS lookup table. However, before the table is finalized, IHRA/PS WG group believes the current lookup table represents the best available information for the head-form impactor test conditions.
The head impact test areas on the vehicle, defined on the basis of wrap around distances for the child and adult head-forms correspond to the areas that accident data shows are commonly struck by the head of a child and an adult pedestrian respectively. The final WAD value derived from the accident data of Australia, Europe, Japan and the US was 1000-1700 mm for child head-form and 1400-2400 mm for adult head-form. Consequently a WAD 1400-1700 mm was shared by both adult and child head-forms and was named “transition zone”. Ishikawa showed that there is no added benefit from having a transition zone instead of a boundary line. So, there was a proposal to leave the use of the transition zone to the discretion of each national government.
The values for head impact velocity, head impact angle and wrap around distances are given in the detail test procedure, which describes the test conditions for the different categories of vehicle shapes and according to the fact that the impacts are on the bonnet or in the windshield.

Injury criteria

For the purpose of this working group, emphasis has been placed on pedestrian head injuries resulting from head impact with the vehicle frontal structure, including the windscreen and the A-pillars. The HIC has been selected as the measure of the risk of brain injuries resulting from such an impact.

HIC has been selected, despite the fact that it doesn't take into account the influence of some factors such as the rotational acceleration of the head, because it is used universally in crash injury research and prevention and the threshold was set at a current 1000 after consideration of existing pass/fail threshold values and the new values being studied by NHTSA.

Taking into account the short duration of this type of head impact, the time window for the HIC calculation has been set at 15 ms. Due to the short duration of the impact, a HIC window of 15ms will normally give the same result as a window of 36 ms, but the 15 ms window will help to reduce the risk of signals from spurious secondary impacts being accidentally included in the calculation

LEG

The IHRA proposal specifies a test method to simulate the impact of the leg of an adult pedestrian against the front face of a passenger car for impact speeds up to 40km/h.

The basic concept is to develop a mechanical impactor, with a controlled motion at knee joint level, to simulate a human knee impact in lateral direction.

The characteristics of the leg-form impactor are that it must be a device representing an adult human leg sensitive to the front face characteristics of a vehicle.

According to the agreement of the IHRA Pedestrian Safety Working group, the physical properties of the impactor are listed below.

Leg-form Specifications

Mass and Dimensions

The IHRA/PS decided that a leg-form used to test vehicle structures should be consistent with the anthropometry of a 50th percentile human leg. The size and mass of a 50th percentile human leg are documented in a report by the University of Michigan Transportation Research Institute (UMTRI), which was used by the IHRA Biomechanics WG. There was considerable discussion about whether the dimensions should reflect a 50th percentile male, 50th percentile female, or an average of the two. It was concluded that since the 50th percentile male is reflective of the most common knee height in pedestrian collisions according to accident data, it would be used in the initially proposed test procedure. The lower leg should be 493 ± 5 mm from bottom of foot to knee joint center, with a center of gravity 233 ± 10 mm from the knee joint center. The thigh should be 428 ± 5 mm long, with a center of gravity 210 ± 10 mm from the knee joint center. The leg-form mass should be 13.4 ± 0.1 kg, divided into 8.6 kg for the thigh (including skin and foam) and 4.8 kg for the lower leg.

Moments of Inertia

Like the mass and dimensions, the moments of inertia are also consistent with the UMTRI anthropometry data. For the tibia, the MOI specification about the y-axis is 0.120 ± 0.001 kg-m^2. For the femur, the specification is 0.127 ± 0.002 kg-m^2. These values are taken with respect to the origin located at the end of each bone. With respect to each individual segment's CG location, the MOI values for the tibia and femur are 0.054 kg-m^2 and 0.132 kg-m^2, respectively

An adapter can be fitted to the top of the thigh to permit the attachment of the leg-form impactor to the propulsion system. If an adapter is used, the thigh with adapter must still comply with the thigh requirements of mass, centre of gravity, and moment of inertia.

There shall be a flesh and/or a skin on the outer surface of the leg-form impactor. This material shall be human-like.

The shape of the leg-form impactor shall be cylindrical. The outer diameter of the thigh and leg shall be the same. Outer diameter is 120 ± 10mm including flesh thickness of 30 ± 5 mm.

Test Procedures

The test will consist of a projectile legform being launched into a stationary vehicle front at a speed consistent with the mean vehicle speed in the pedestrian accident data.

The direction of the impact velocity vector shall be in the horizontal plane and parallel to the longitudinal vertical plane of the vehicle. The axis of the leg-form shall be perpendicular to the horizontal plane with a tolerance of ±2° in the lateral and longitudinal plane (see Figure 15). The horizontal, longitudinal and lateral planes are orthogonal to each other.

The bottom of the leg-form impactor shall be at 25mm above the Ground Reference Level at the time of first contact with the bumper (see Figure 16), with a ± 10 mm tolerance.

When setting the height of the propulsion system, an allowance must be made for the influence of gravity during the period of free flight of the leg-form impactor.

At the time of first contact the impactor shall have the intended orientation about its vertical axis, for the correct operation of its knee joint with a tolerance of ± 5° (see Figure 15)

Tests shall be made to the front face of the vehicle, between the bumper corners. The center of each impact shall be a minimum of half leg-form diameter inside defined bumper corners. Sufficient test points shall be selected to evaluate the vehicle structure.

This test method is intended to cover impact velocity up to 40 km/h. The velocity of the impactor shall be measured at some point during the free flight before impact.

The IHRA PS WG discussed application of an upper body mass to the legform to simulate the upper body of the pedestrian.

While the group maintained that upper body mass should not be included when looking at lower leg and knee impacts, it was agreed that this issue would be re-opened at a time when it is necessary to look at upper leg/thigh injury.

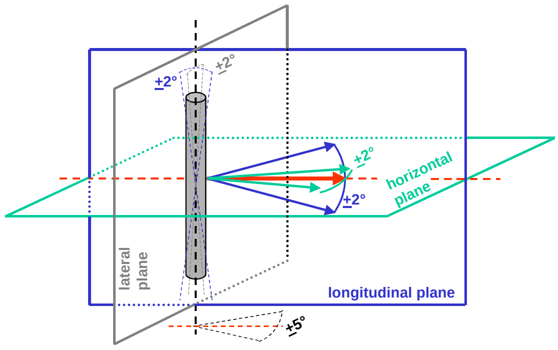

Figure 15.
During contact between the leg-form impactor and the vehicle, the leg-form impactor shall not contact the ground or any object not part of the vehicle.

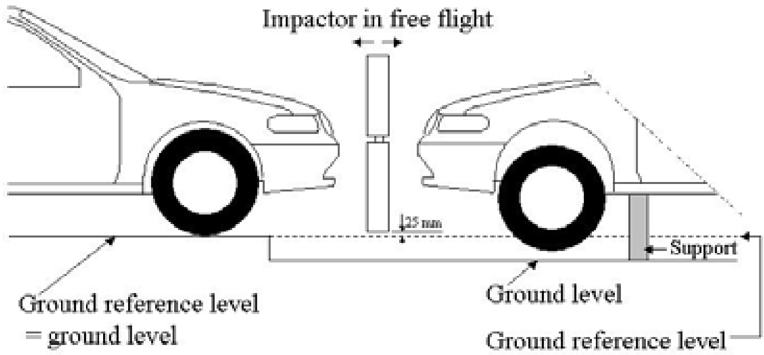

Figure 16.
Legform to bumper tests for complete vehicle in normal ride attitude (left) and for complete vehicle or sub-system mounted on supports (right)

Dynamic Response Corridors

The University of Virginia conducted a number of tests assessing the response of the human leg in a bending mode. Historical PMHS data was also used to generate adapted time history corridors in both bending and shearing modes. Dynamic response corridors were created and normalized for;

- Force vs. Deflection (Lower Leg and Thigh)
- Moment vs. Deflection (Lower Leg and Thigh)
- Knee Moment vs. Angle
- Impact Force vs. Time (Bending & Shearing Mode, 20 and 40 km/hr)
- Bending Angle vs. Time (Bending Mode, 20 and 40 km/hr)
- Shear Displacement vs. Time (Shearing Mode, 20 and 40 km/hr)

Bio-ranking method

A Bio-ranking method was developed by NHTSA to quantitatively and objectively evaluate leg-form impactor biofidelity using dynamic response corridors and impactor response data. The leg-form impactor should have a sufficiently high biofidelic score to conduct to properly assess leg injury potential due to vehicle impact.

Injury Risk Curves

Injury risk curves were developed by the University of Virginia for the thigh and lower leg using logistic regression. They developed two sets of risk curves for the knee and lower leg, one using maximum moment and the other using an acoustic sensor to detect the time of injury.

CONTINUATION OF IHRA/PS ACTIVITIES

The aim of the IHRA/PS WG is to propose test procedures for the child and adult head, and the adult leg as the high priority body regions, for presentation at the ESV Conference in 2003 and 2005, together with recommendations for research activities that will be needed to develop other test procedures for the further improvement of pedestrian protection.

In the field of pedestrian crash injury biomechanics there are still areas which must be investigated and their practical applications explored. We plan to first clarify the issues, necessities and research responsibilities through detailed investigations. The following issues will be studied.

(1) Methods employing a computer simulation program based on the best such programs currently available.

(2) Clarification of the importance of injury mechanisms to areas other than the head or legs; also, R&D on impactors to confirm such injury mechanisms

(3) The Research for Adult Leg vs. High Bumper vehicles Test method and its tool
1st step: Analyze the current IHRA Adult Leg test method limitation using computer simulation model. Comparative evaluation of the results of, and interactions between, subsystem test methods and test
2nd step: If the current Adult Leg test method can not apply for the high bumper vehicles, an Adult Leg test method for the high bumper vehicles and tools will be developed.

(4) Development of the Adult Upper Leg vs. BLE test method
1st step, focusing on in-depth study for pedestrian accidents for these area, and if we find out the necessity of the development of the test method and tool, we will conduct such research to develop the test method and its tool.

This work will be greatly facilitated if member countries are prepared to cooperate and share the cost, conduct further studies, and assist in the development of essential test procedures.

Table 11.
Members of IHRA Pedestrian Safety WG

Name	Organization
Chair person, Yoshiyuki Mizuno	JASIC Japan
Jack McLean	University of Adelaide Australia
Dominique Cesari	INRETS EEVC/EC
Graham Lawrence	TRL EEVC/EC
Bruce Donnelly	NHTSA USA
Hirotoshi Ishikawa	JARI Japan
Atsuhiro Konosu	JARI Japan
Oskar Ries	VW ACEA
Françoise Brun-Cassan	LAB,PSA/RENAULT ACEA
Masaaki Tanahashi	Honda R&D JAMA/Japan
Sukhbir Bilkhu	Daimler Chrysler AAM
Yoshihiro Yazawa	Nissan/JASIC Japan

Predecessor, contributed to the IHRA/PS-WG

Akira Sasaki (1996-2000)	Honda R&D JAMA/Japan
Roger Saul (1996-2000)	NHTSA USA
Hirotoshi Ishimaru (1996-2000)	JSAE Japan
Norbert Jaehn (1996-2000)	ACEA
Manuel Bartolo (1996-2000)	Ford AAM
Jacques Provensal (1999-2001)	ACEA
Edgar Janssen (1996-2002)	TNO EEVC/EC

Reference:

International Harmonized research Activities, Pedestrian safety Working group 2005 Report